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Nakajima et al.

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[54] **LIQUID CRYSTAL DISPLAY**

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[73] Assignee: **Sony Corporation**, Tokyo, Japan

[21] Appl. No.: **09/141,323**

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[30] **Foreign Application Priority Data**

Aug. 19, 1997 [JP] Japan 9-233518

[51] **Int. Cl.**[7] **G09G 3/36**; G09G 5/00

[52] **U.S. Cl.** **345/96**; 345/209; 345/98

[58] **Field of Search** 345/96, 209, 87–104

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Primary Examiner—Mark R. Powell
Assistant Examiner—Anthony J Blackman
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[57] **ABSTRACT**

Since each driving circuit has corresponded to the entire range of signal voltage, the dynamic range is large, it is difficult to constitute it by high Vth transistors, and a circuit having sufficient driving capacity for both input and output of current must be used, leading to increased circuit area and current consumption. To solve the problem, a circuit for driving column lines is divided into two in response to signal voltage with, for example, the common voltage as a reference, and these two column line driving circuits are arranged on the upper and lower sides of the LCD effective screen portion every two columns, and when the output end of the one column line driving circuit is connected to one of two column lines the analog switches are open-close timing controlled so that the output end of the other column line driving circuit is connected to the other of the two column lines.

16 Claims, 4 Drawing Sheets

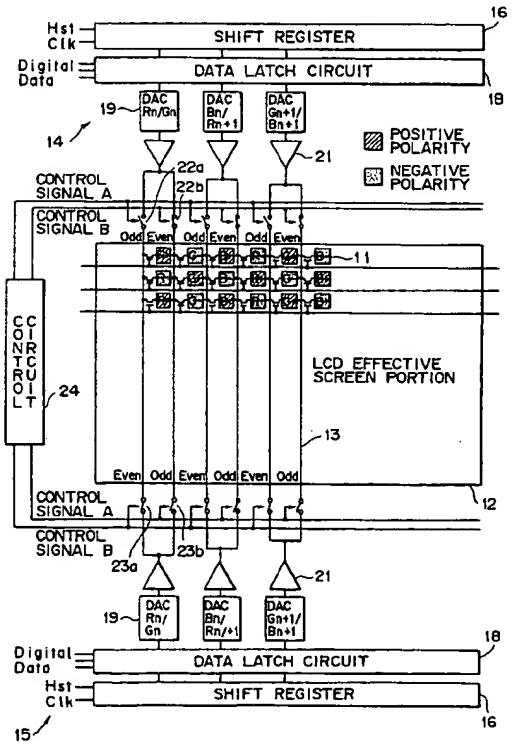
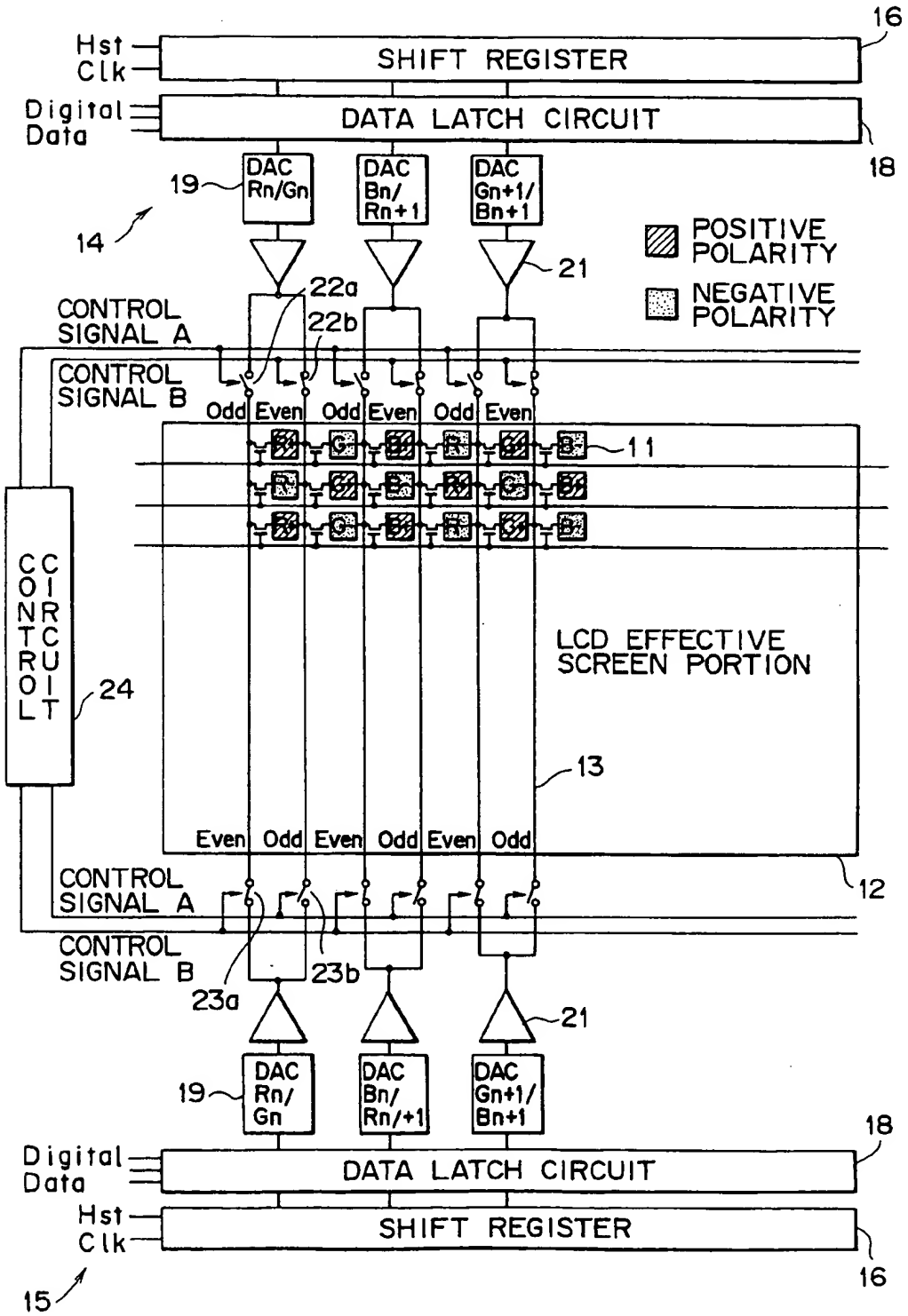


FIG. 1


16
Hst
Clk
SHIFT REGISTER
Digital
Data
DATA LATCH CIRCUIT
18
19
DAC
Rn/Gn
DAC
Bn/
Rn+1
DAC
Gn+1/
Bn+1
14
POSITIVE
POLARITY
NEGATIVE
POLARITY
21
22a
22b
CONTROL
SIGNAL A
CONTROL
SIGNAL B
Odd Even Odd Even Odd Even
11
CONTROL
CIRCUIT
24
LCD EFFECTIVE
SCREEN PORTION
13
Even Odd Even Odd Even Odd
12
CONTROL
SIGNAL A
CONTROL
SIGNAL B
23a
23b
21
19
DAC
Rn/
Gn
DAC
Bn/
Rn/+1
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Bn+1
18
Digital
Data
DATA LATCH CIRCUIT
Hst
Clk
SHIFT REGISTER
16
15

FIG. 2

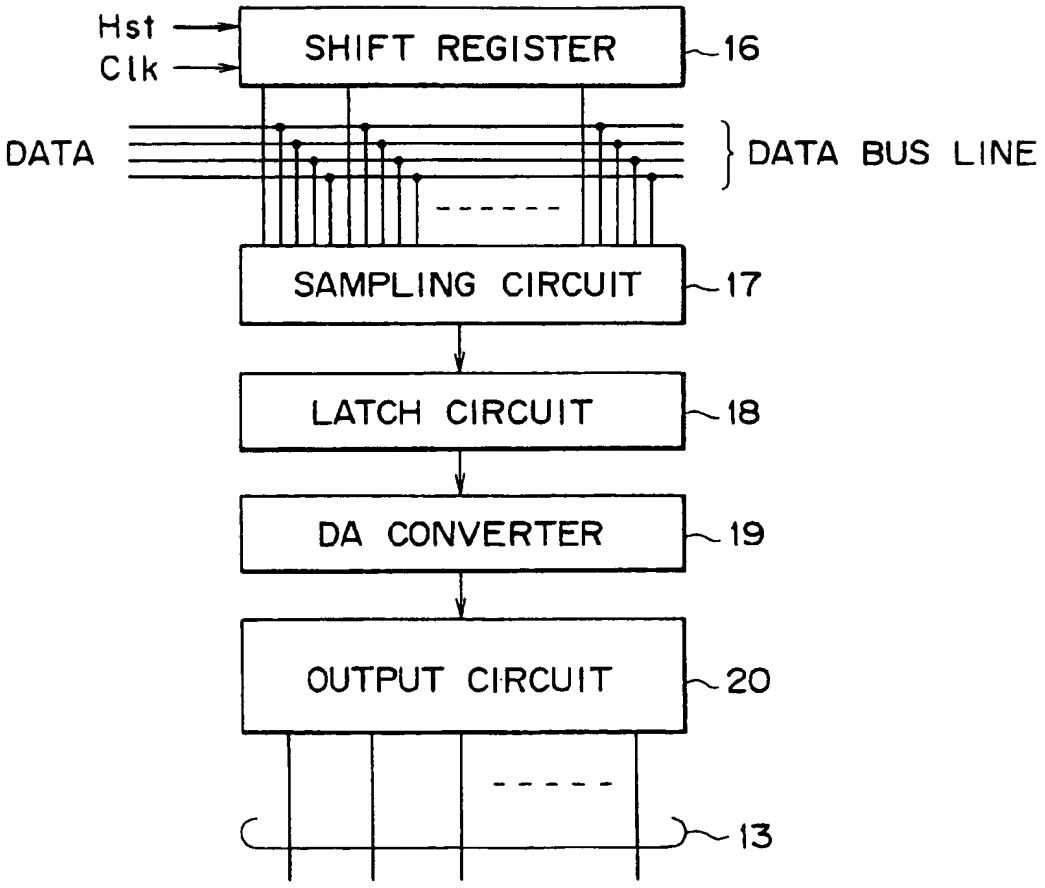

Hst
Clk
SHIFT REGISTER
16
DATA
DATA BUS LINE
SAMPLING CIRCUIT
17
LATCH CIRCUIT
18
DA CONVERTER
19
OUTPUT CIRCUIT
20
13

FIG. 3

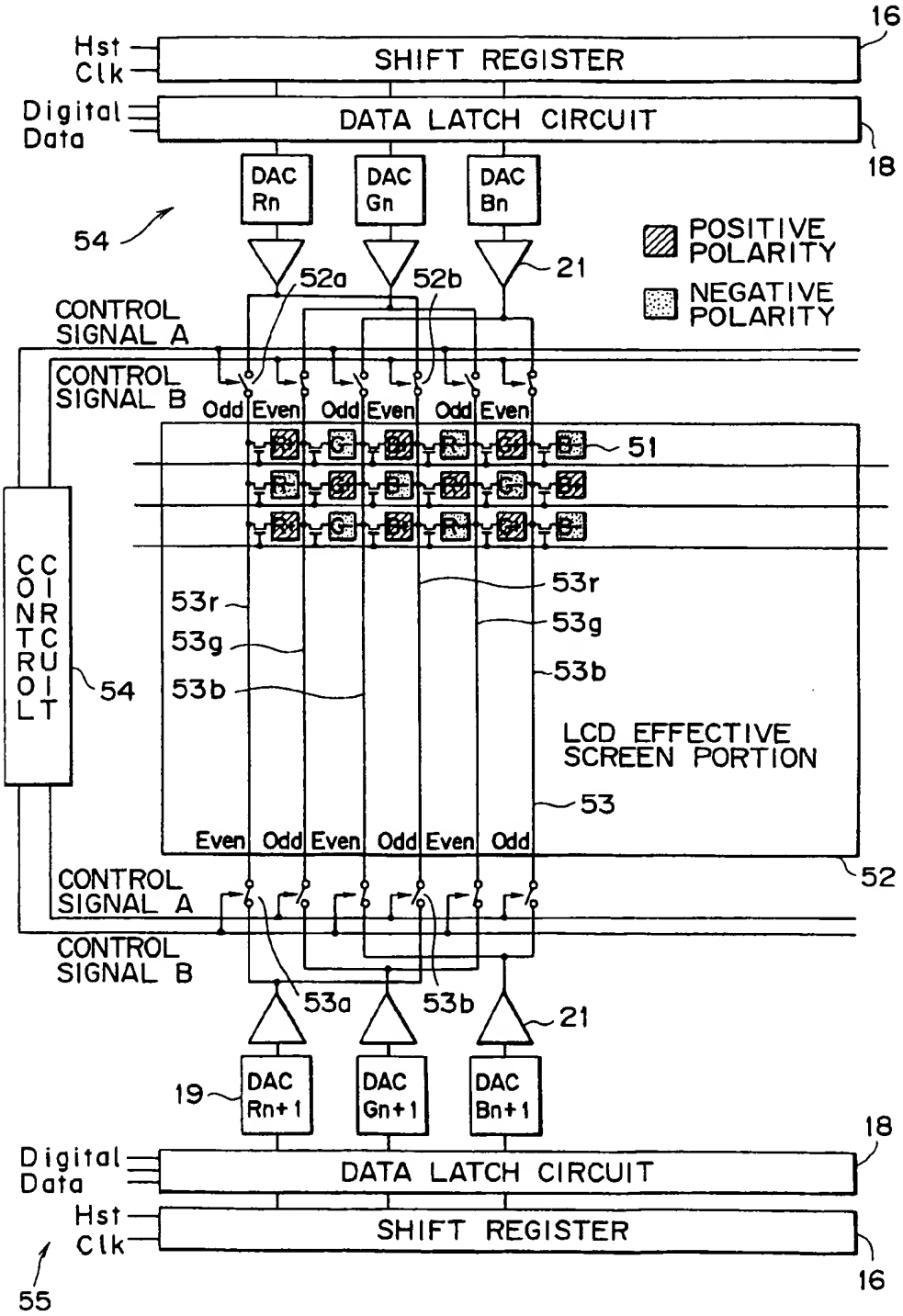
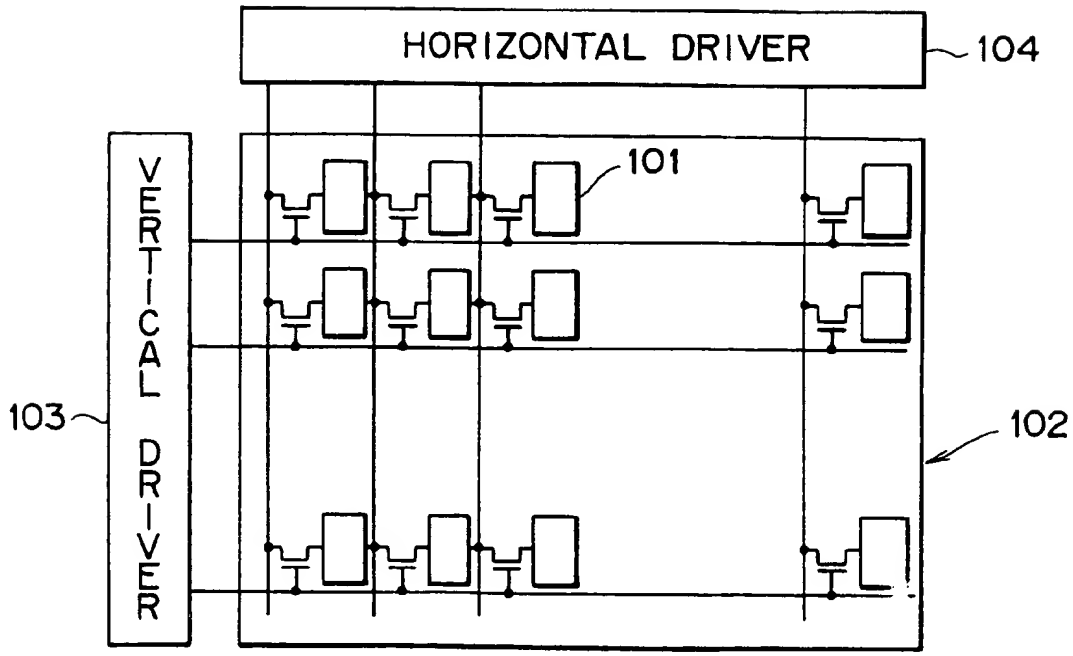

16
Hst
Clk
SHIFT REGISTER
Digital
Data
DATA LATCH CIRCUIT
18
DAC Rn
DAC Gn
DAC Bn
54
POSITIVE POLARITY
NEGATIVE POLARITY
52a
52b
21
CONTROL SIGNAL A
CONTROL SIGNAL B
Odd Even Odd Even Odd Even
51
CONTROL CIRCUIT
54
53r
53g
53b
LCD EFFECTIVE SCREEN PORTION
53
Even Odd Even Odd Even Odd
52
CONTROL SIGNAL A
CONTROL SIGNAL B
53a
53b
21
19
DAC Rn+1
DAC Gn+1
DAC Bn+1
18
Digital
Data
DATA LATCH CIRCUIT
Hst
Clk
SHIFT REGISTER
16
55

FIG. 4



LIQUID CRYSTAL DISPLAY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a driving circuit for a liquid crystal display (hereinafter, referred to as LCD), and more particularly to a column line driving circuit for an active matrix LCD.

2. Description of Related Art

FIG. **4** shows an example of the structure of the active matrix LCD. In FIG. **4**, a LCD panel **102** is constituted by two-dimensionally arranging liquid crystal cells (pixels) **101** in a matrix shape. On the periphery of this LCD panel **102**, there are provided a vertical driver **103** for selecting rows, and a horizontal driver (hereinafter, referred to as column line driving circuit) **104** for selecting columns. As regards the column line driving circuit **104**, it has heretofore been arranged only on the upper side of the LCD panel **102** as shown in the same figure, or the same one each is arranged on both the upper and lower sides thereof, and each driving circuit has been adapted to correspond to the entire range of signal voltage applied to the LCD.

In the conventional column line driving circuit constructed as described above, however, since each driving circuit is to cover a minimum level to a maximum level of signal voltage, the dynamic range is large.

In order to produce a column line driving circuit with such a large dynamic range, transistors with low threshold voltage Vth must be used, and it is difficult to constitute the column line driving circuit by transistors with such high threshold voltage Vth as a polysilicon TFT (Thin Film Transistor). Moreover, since the number of circuit elements is great, it is very difficult to realize using such an element with a large variation in characteristics as polysilicon TFT. Also, even in case where it is produced using monocrystal silicon, a circuit (for example, push-pull circuit) having sufficient driving ability must be used for both input and output of current, and therefore, both circuit area and current consumption will be increased.

SUMMARY OF THE INVENTION

The present invention has been achieved in the light of the above-described problems, and is aimed to provide a LCD driving circuit in which it is easy to produce a circuit using transistors with high threshold voltage Vth, and capable of reducing the circuit area and power consumption.

A LCD driving circuit according to the present invention comprises a first column line driving circuit, arranged for every two column lines on one of the upper and lower sides of a LCD effective screen portion, for driving the column line for a larger signal than predetermined reference voltage; a second column line driving circuit, arranged for every two column lines on the other of the upper and lower sides of the LCD effective screen portion, for driving the column line for a smaller signal than the predetermined reference voltage; a first pair of analog switches connected between the output end of the first column line driving circuit and the two column lines; a second pair of analog switches connected between the output end of the second column line driving circuit and the two column lines; and a control circuit for open-close controlling the first and second pair of analog switches respectively so that when the output end of the first column line driving circuit is connected to one of the two column lines, the output end of the second column line driving circuit is connected to the other of the two column lines.

In the LCD driving circuit constructed as described above, when the output end of the first column line driving circuit for a larger signal voltage than predetermined reference voltage (for example, common voltage) is connected to one of the two column lines, the first and second pair of analog switches are open-close timing controlled so that the output end of the second column line driving circuit for smaller signal voltage is connected to the other of the two column lines, whereby the first column line driving circuit operates as a sweep-off driving circuit, and the second column line driving circuit operates as a lead-in driving circuit. As a result, the output buffer for the first or second column line driving circuit can be constituted by only a circuit (for example, source follower circuit) excellent only in current driving in one side direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic structural view showing a first embodiment according to the present invention;

FIG. **2** is a block diagram showing an example of the structure of a column line driving circuit;

FIG. **3** is a schematic structural view showing a second embodiment according to the present invention; and

FIG. **4** is a schematic structural view showing an example of an active matrix LCD.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, with reference to the drawings, the detailed description will be made of embodiments of the present invention.

FIG. **1** is a schematic structural view showing a first embodiment according to the present invention. In FIG. 1, a LCD effective screen portion **12** is constituted by two-dimensionally arranging liquid crystal cells (pixels)**11** in a matrix shape. Above each liquid crystal cell **11**, there are arranged striped color filters (not shown) of R (Red), G (Green) and B (Blue) A circuit for driving column lines **13** is divided into two in response to signal voltage, for example, with common voltage applied to the common electrode of the liquid crystal as a reference.

More specifically, the circuit is divided into a first column line driving circuit **14** corresponding to higher signal voltage than the common voltage, and a second column line driving circuit **15** corresponding to lower signal voltage than the common voltage. For example, the first column line driving circuit **14** is arranged on the upper side of the LCD effective screen portion **12**, and the second column line driving circuit **15** is arranged on the lower side of the LCD effective screen portion **12** in such a manner that they operate in parallel.

The first or second column line driving circuit **14** or **15** comprises, as shown in FIG. **2**, a shift register **16** for outputting sampling pulses in order, a sampling circuit **17** for sampling the data on a data bus line in synchronization with sampling pulses given from this shift register **16** in order, a latch circuit **18** for retaining these sampling data during one horizontal period, a DA converter **19** for converting the latch data into an analog signal, and an output circuit **20** for driving a load on the column line (signal conductor) **13**.

One each of the DA converter **19** and the output circuit **20** for the first or second column line driving circuit **14** or **15** are arranged for every two columns. More specifically, as can be seen from FIG. 1, each output buffer **21** constituting the output circuit **20** is arranged for two column lines **13** and **13** which are adjacent each other. The DA converters **19** are also

arranged by a number corresponding to the number of the output buffers **21**.

There are connected a pair of analog switches **22***a*, **22***b* between the output end of the output buffer **21** on the side of the first column line driving circuit **14** and two column lines **13**, **13** which are adjacent to each other. Likewise, there are connected a pair of analog switches **23***a*, **23***b* between the output end of the output buffer **21** on the side of the second column line driving circuit **15** and these two column lines **13**, **13**. The pair of analog switches **22***a*, **22***b* are open-close timing controlled through control signals A, B outputted from a control circuit **24**, and likewise, the pair of analog switches **23***a*, **23***b* are also open-close timing controlled through control signals B, A.

Concretely, when the output end of the output buffer **21** of the first column line driving circuit **14** is connected to the column line **13** at an odd step, timing is controlled so that the output end of the output buffer **21** of the second column line driving circuit **15** is connected to the column line **13** at an even step. Conversely, when the output end of the output buffer **21** of the second column line driving circuit **15** is connected to the column line **13** at an odd step, timing is controlled so that the output end of the output buffer **21** of the first column line driving circuit **14** is connected to the column line **13** at an even step.

When electric charge is given to the column line **13***n* at a n-th step using the first column line driving circuit **14** under this timing control, the electric charge on the column line **13***n*+1 at a (n+1) th step can be discharged using the second column line driving circuit **15**, and when electric charge is given to the column line **13***n*+1 at a (n+1)th step using the first column line driving circuit **14** at another timing, the electric charge on the column line **13***n* at a n-th step can be discharged using the second column line driving circuit **15**. In other words, the first column line driving circuit **14** operates as a sweep-off driving circuit, while the second column line driving circuit **15** operates as a lead-in driving circuit.

The connection of the output end of the output buffer **21** of the first column line driving circuit **14** to the column line at the odd step or at the even step, and the connection of the output end of the output buffer **21** of the second column line driving circuit **15** to the column line **13** at the even step or at the odd step, are switched for each horizontal period respectively, whereby dot reverse driving can be performed. Here, the dot reverse means a state in which pixels adjacent to each other in the two-dimensional array of liquid crystal cells (pixels) **11** alternately become positive or negative in polarity as shown in FIG. **1**.

As described above, a circuit for driving the column lines **13** is divided into two in response to signal voltage with, for example, the common voltage as a reference, and one each of these two column line driving circuits **14**, **15** are arranged for every two column lines on the upper and lower sides of the LCD effective screen portion **12**, and when the output end of the one column line driving circuit **14** is connected to one of these two column lines, the analog switches **22***a*, **22***b* and **23***a*, **23***b* are open-close timing controlled so that the output end of the other column line driving circuit **15** is connected to the other of the two column lines, whereby the dot reverse driving can be easily performed, and yet the area efficiency is good because there are few circuits at rest.

The output buffer **21** can be constituted only by a circuit in which it is limited to sweep- off or lead-in of current, that is, a circuit (for example, source follower circuit) excellent only in current driving in one side direction. This provides the following effects:

(1) Even in case where such high Vth transistors as polysilicon TFT are used, a system in which the output dynamic range has been sufficiently secured can be easily constructed. As a result, it becomes useful particularly when a driving circuit is integrally formed on a polysilicon LCD.

(2) Since the circuit can be constituted by a minimum quantity of elements, an output buffer **21**, which is less affected by variation in transistor can be constituted.

(3) Since the DA converter **19** and the output buffer **21** can be operated within a limited voltage range, it is possible to simplify the circuit configuration and to reduce the circuit area.

(4) Since the output buffer **21** can be constituted by minimum DC current, it is possible to reduce the power consumption.

Further, when in the first and second column line driving circuits **14**, **15**, a reference voltage selection type DA converter is used as the DA converter **19**, the following effects can be obtained:

(1) The area can be reduced because a reference voltage line can be set only to voltage within a range covered by the column line driving circuit **14**, **15**.

(2) A switch used as a reference voltage selector can be constituted only by a NMOS transistor or a PMOS transistor, to thereby make it possible to reduce the area.

In this respect, in the above-described embodiment, the description has been made of the case in which the first column line driving circuit **14** for corresponding to a higher signal voltage than the common voltage is arranged on the upper side of the LCD effective screen portion **12**, and in which the second column line driving circuit **15** for corresponding to a lower signal voltage than the common voltage is arranged on the lower side of the LCD effective screen portion **12**, but the arrangement may be reversed as a matter of course.

Also, in the above-described embodiment, the predetermined reference voltage for dividing the first and second column line driving circuits **14**, **15** has been set to the common voltage applied to the common electrode of a liquid crystal, but the voltage which is made as the reference for division is not limited to the common voltage but any voltage near signal center voltage may be used.

Further, in the above-described embodiment, the connection of the output end of the output buffer **21** of the first column line driving circuit **14** to the column line **13***o* or **13***e*, and the connection of the output end of the output buffer **21** of the second column line driving circuit **15** to the column line **13***e* or **13***o*, have been switched for each horizontal period respectively, but the connection may be switched for each field.

FIG. **3** is a schematic structural view showing a second embodiment according to the present invention. In FIG. **3**, on the upper side of a LCD effective screen portion **52** comprising liquid crystal cells (pixels) **51** two-dimensionally arranged in a matrix shape, a first column line driving circuit **54** for corresponding to higher signal voltage than the common voltage is arranged, and on the lower side of the LCD effective screen portion **52**, a second column line driving circuit **55** for corresponding to lower signal voltage than the common voltage is arranged, and the DA converters and output circuits for the first and second column line driving circuits **14**, **15** are arranged for every two column lines respectively in such a manner that they operate in parallel as in the case of the first embodiment.

In the above-described structure, as the first or second column line driving circuit **54** or **55**, a circuit having the circuit configuration shown in , for example, FIG. **2** is used. A DA converter **19** and an output buffer **21** for the first or second column line driving circuit **54** or **55** are arranged for every two adjacent columns of the same color respectively. More specifically, as can be seen from FIG. **3**, one each of output buffer **21** is arranged for two adjacent column lines **53** and **53** of the same color. The DA converters **19** are also arranged by a number corresponding to the number of the output buffers **21**.

Between the output end of the output buffer **21** on the side of the first column line driving circuit **54**, and two column lines **53***r*, **53***r* of, for example, R color which are adjacent to each other, there are connected a pair of analog switches **52***a*, **52***b*. Likewise, between the output end of the output buffer **21** on the side of the second column line driving circuit **55** and those two column lines **53***r*, **53***r*, there are connected a pair of analog switches **53***a*, **53***b*. As regards G color and B color, a pair of analog switches **52***a*, **52***b*, and **53***a*, **53***b* are connected in quite the same manner as in the case of R color.

The pair of analog switches **52***a*, **52***b* are open-close timing controlled through control signal A, B outputted from a control circuit **54**, and likewise, the pair of analog switches **53***a*, **53***b* are also open-close timing controlled through control signal B, A. Concretely, as regards R color, when the output end of the output buffer **21** of the first column line driving circuit **54** is connected to the column line **53***r* at an odd step, timing control is made so that the output end of the output buffer **21** of the second column line driving circuit **55** is connected to the column line **53***r* at an even step.

Conversely, when the output end of the output buffer **21** of the second column line driving circuit **55** is connected to the column line **53***r* at an odd step, timing control is made so that the output end of the output buffer **21** of the first column line driving circuit **54** is connected to the column line **53***r* at an even step. As regards C color and B color, the same timing control as in the case of R color is performed.

As described above, a circuit for driving the column line **53** is divided into two in response to signal voltage with, for example, the common voltage as a reference, and these two column line driving circuits **54**, **55** are arranged on the upper and lower sides of the LCD effective screen portion **52** every two column lines, and when the output end of the one column line driving circuit **54** is connected to one of the two column lines, the analog switches **52***a*, **52***b* and **53***a*, **53***b* are open-close timing controlled so that the output end of the other column line driving circuit **55** is connected to the other of the two column lines, whereby the same operative effect as in the case of the first embodiment can be obtained.

In addition to the foregoing, this embodiment is arranged such that the column lines, to which the output circuit **20** of the first or second column line driving circuit **54**, **55** is connected, are not two adjacent columns, but two adjacent columns of the same color in such a manner that switching between the column lines of the same color is performed, and therefore, there is an advantage that there is no need for switching between data signals for different colors.

In this respect, the output circuit of each column line driving circuit has been connected to the two adjacent columns in the first embodiment, and to the two adjacent columns of the same color in the second embodiment, but the present invention is not limited to these columns, but two any adjacent columns may be used so long as the control signals A, B for a pair of analog switches arranged on the upper and lower sides of the column lines are different from each other in polarity.

As described above, the present invention is constructed such that a circuit for driving column lines is divided into two in response to signal voltage, and these two column line driving circuits are arranged on the upper and lower sides of the LCD effective screen portion every two columns, and that when the output end of the one column line driving circuit is connected to one of those two column lines, timing control is performed so that the output end of he other column line driving circuit is connected to the other of the two column lines, whereby the output buffer can be operated within a limited voltage range, and yet the output buffer can be constituted by only a circuit excellent only in current driving in one side direction. Therefore, it becomes easy to form a circuit using high Vth transistors, and it is possible to reduce the circuit area and the power consumption.

What is claimed is:

1. A liquid crystal display comprising:

a first column line driving circuit, arranged for every two column lines, for driving the column line for a larger signal than a predetermined reference voltage;

a second column line driving circuit, arranged for every two column lines, for driving the column line for a smaller signal than said predetermined reference voltage;

a first pair of analog switches connected between the output end of said first column line driving circuit and the two column lines;

a second pair of analog switches connected between the output end of said second column line driving circuit and the two column lines; and

a control circuit for open-close controlling said first and second pair of analog switches respectively so that when the output end of said first column line driving circuit is connected to one of the two column lines, the output end of said second column line driving circuit is connected to the other of the two column lines.

2. A liquid crystal display as claimed in claim **1**, wherein said predetermined reference voltage is common voltage to be applied to the common electrode of a liquid crystal, or any voltage in the vicinity of signal center voltage.

3. A liquid crystal display as claimed in claim **1**, wherein said two column lines are two column lines which are adjacent to each other.

4. A liquid crystal display as claimed in claim **1**, wherein said two column lines are two column lines of the same color which are adjacent to each other.

5. A liquid crystal display as claimed in claim **1**, wherein the connection of said control circuit to the column line at the output end of said first or second column line driving circuit is switched for each horizontal period or for each field period.

6. A liquid crystal display as claimed in claim **1**, wherein said first and second column line driving circuits comprise source follower circuits.

7. A liquid crystal display as claimed in claim **1**, wherein said first column line driving circuit is for discharging and said second column line driving circuit is for charging.

8. A liquid crystal display as claimed in claim **1**, wherein said liquid crystal display is dot-inversion driven.

9. A liquid crystal display comprising:

a first column line driving circuit, arranged for every two column lines on one of the upper and lower sides of an effective screen portion, for driving the column line for a larger signal than a predetermined reference voltage;

a second column line driving circuit, arranged for every two column lines on the other of the upper and lower

sides of said effective screen portion, for driving the column line for a smaller signal than said predetermined reference voltage;

a first pair of analog switches connected between the output end of said first column line driving circuit and the two column lines;

a second pair of analog switches connected between the output end of said second column line driving circuit and the two column lines; and

a control circuit for open-close controlling said first and second pair of analog switches respectively so that when the output end of said first column line driving circuit is connected to one of the two column lines, the output end of said second column line driving circuit is connected to the other of the two column lines.

10. A liquid crystal display as claimed in claim **9**, wherein s aid predetermined reference voltage is common voltage to be applied to the common electrode of a liquid crystal, or any voltage in the vicinity of signal center voltage.

11. A liquid crystal display as claimed in claim **9**, wherein said two column lines are two column lines which are adjacent to each other.

12. A liquid crystal display as claimed in claim **9**, wherein said two column lines are two column lines of the same color which are adjacent to each other.

13. A liquid crystal display as claimed in claim **9**, wherein the connection of said control circuit to the column line at the output end of said first or second column line driving circuit is switched for each horizontal period or for each field period.

14. A liquid crystal display as claimed in claim **1**, wherein said first and second column line driving circuits comprise source follower circuits.

15. A liquid crystal display as claimed in claim **1**, wherein said first column line driving circuit is for discharging and said second column line driving circuit is for charging.

16. A liquid crystal display as claimed in claim **1**, wherein said liquid crystal display is dot-inversion driven.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,157,358
DATED : December 5, 2000
INVENTOR(S) : Nakajima et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [30], should read;
-- [30] **Foreign Application Priority Data**
Aug. 29, 1997 [JP] Japan 9-233518 --

Signed and Sealed this

Ninth Day of April, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office